

## CLAIMS

What is claimed is:

- 1 1. A method comprising:
  - 2 inputting speech representing an utterance and having an intonation; and
  - 3 identifying an endpoint of the utterance based on the intonation.
- 1 2. A method as recited in claim 1, wherein said identifying an endpoint of the
  - 2 utterance based on the intonation comprises comparing the intonation with an
  - 3 intonation model.
- 1 3. A method as recited in claim 4, further comprising determining the intonation
  - 2 by computing the fundamental frequency of the utterance.
- 1 4. A method as recited in claim 3, wherein said determining the intonation
  - 2 comprises using an intonation model to determine the intonation.
- 1 5. A method as recited in claim 1, wherein said identifying the endpoint of the
  - 2 utterance comprises identifying the endpoint of the utterance based on a plurality
  - 3 of knowledge sources, wherein one of the knowledge sources is intonation,
  - 4 including referencing the input speech against a histogram based on training data
  - 5 for each of the knowledge sources.
- 1 6. A method as recited in claim 1, further comprising:
  - 2 determining a period of time that has elapsed since the speech dropped
  - 3 below a threshold value; and
  - 4 wherein said identifying an endpoint of the utterance comprises identifying
  - 5 the endpoint of the utterance further based on the period of time.
- 1 7. A method as recited in claim 1, wherein said identifying an endpoint of the
  - 2 utterance comprises identifying the endpoint of the utterance further based on a

3 length of time for which an energy value of the speech has remained below a  
4 predetermined energy value.

1 8. A method as recited in claim 7, wherein said identifying an endpoint of the  
2 utterance further comprises identifying the endpoint of the utterance based on the  
3 duration of the final syllable of the utterance.

1 ~~9.~~ A method of operating an endpoint detector, the method comprising:  
2 inputting speech representing an utterance, the utterance having an  
3 intonation; and  
4 comparing the intonation of the utterance with an intonation model;  
5 determining a probability based on a result of said comparing; and  
6 identifying an endpoint of the utterance based on the probability.

1 10. A method as recited in claim 9, further comprising determining the intonation  
2 of the utterance as a function of the fundamental frequency of the utterance.

1 11. A method as recited in claim 9, further comprising:  
2 determining a period of time that has elapsed since a value of the speech  
3 dropped below a threshold value; and  
4 wherein said identifying an endpoint of the utterance comprises identifying  
5 the endpoint of the utterance further based on the period of time.

1 12. A method as recited in claim 9, wherein said identifying an endpoint of the  
2 utterance comprises identifying the endpoint of the utterance further based on the  
3 duration of the final syllable of the utterance.

1 13. A method as recited in claim 12, wherein said identifying an endpoint of the  
2 utterance comprises identifying the endpoint of the utterance further based on a

3 period of time for which an energy value of the speech has remained below a  
4 threshold value.

1 14. A method of operating an endpoint detector for speech recognition, the  
2 method comprising:

3 inputting speech representing an utterance;

4 determining that a value of the speech has dropped below a threshold  
5 value;

6 computing an intonation of the utterance;

7 referencing the intonation of the utterance against an intonation model to

8 determine a first end-of-utterance probability;

9 determining a period of time that has elapsed since the value of the speech  
10 dropped below the threshold value;

11 referencing the period of time against an elapsed time model to determine a  
12 second end-of-utterance probability;

13 computing an overall end-of-utterance probability as a function of the first  
14 and second end-of-utterance probabilities; and

15 determining whether an end-of-utterance has occurred based on the overall  
16 end-of-utterance probability.

1 15. A method as recited in claim 14, wherein said computing an intonation of the  
2 utterance comprises computing an intonation of the utterance by determining the  
3 fundamental frequency of the utterance as a function of time.

1 16. A method as recited in claim 15, further comprising:

2 determining a duration of a final syllable of the utterance; and

3 referencing the duration of the final syllable against a syllable duration  
4 model to determine a third end-of-utterance probability;

5 wherein said computing an overall end-of-utterance probability comprises  
6 computing the overall end-of-utterance probability as a function of the first,  
7 second, and third end-of-utterance probabilities.

1 17. A method of operating an endpoint detector for speech recognition, the  
2 method comprising:  
3     inputting speech representing an utterance;  
4     computing an intonation of the utterance;  
5     referencing the intonation of the utterance against an intonation model to  
6     determine a first end-of-utterance probability;  
7     determining a duration of a final syllable of the utterance;  
8     referencing the duration of the final syllable against a syllable duration  
9     model to determine a second end-of-utterance probability;  
10     computing an overall end-of-utterance probability as a function of the first  
11     and second end-of-utterance probabilities; and  
12     determining whether an end-of-utterance has occurred based on the overall  
13     end-of-utterance probability.

1 18. A method as recited in claim 17, wherein said computing an intonation of the  
2 utterance comprises computing an intonation of the utterance by determining the  
3 fundamental frequency of the utterance as a function of time.

1 19. A method as recited in claim 17, further comprising:  
2     determining that a value of the speech has dropped below a threshold  
3     value;  
4     determining a period of time that has elapsed since the value of the speech  
5     dropped below the threshold value; and  
6     referencing the period of time against an elapsed time model to determine a  
7     second end-of-utterance probability;  
8     wherein said computing an overall end-of-utterance probability comprises  
9     computing the overall end-of-utterance probability as a function of the first,  
10     second, and third end-of-utterance probabilities.

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20. A method of operating an endpoint detector for speech recognition, the  
method comprising:  
inputting speech representing an utterance, the utterance having a time-  
varying fundamental frequency;  
determining that a value of the speech has dropped below a threshold  
value;  
computing an intonation of the utterance by determining the fundamental  
frequency of the utterance as a function of time;  
referencing the intonation of the utterance against an intonation model to  
determine a first end-of-utterance probability;  
determining a period of time that has elapsed since a value of the speech  
dropped below the threshold value;  
referencing the period of time against an elapsed time model to determine a  
second end-of-utterance probability;  
determining a duration of a final syllable of the utterance;  
referencing the duration of the final syllable against a syllable duration  
model to determine a third end-of-utterance probability;  
computing an overall end-of-utterance probability as a function of the first,  
second, and third end-of-utterance probabilities; and  
determining whether an end-of-utterance has occurred by comparing the  
overall end-of-utterance probability to a threshold probability.

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21. A method of operating an endpoint detector for speech recognition, the  
method comprising:  
inputting speech representing an utterance;  
determining an intonation of the utterance;  
if the intonation of the utterance is determined to be generally decreasing,  
then setting a threshold time period equal to a first time value;  
if the intonation of the utterance is determined not to be generally  
decreasing, then setting the threshold time period equal to a second time value  
larger than the first time value; and

10 identifying an endpoint of the utterance based on the threshold time  
11 period.

1 22. A method as recited in claim 21, wherein said using the threshold time period  
2 to identify an endpoint of the utterance comprises using the threshold time period  
3 to identify an endpoint of the utterance by determining that an endpoint of the  
4 utterance has occurred if an energy value of the speech remains below a  
5 predetermined value for the threshold time period.

1 23. A method as recited in claim 21, wherein said determining an intonation of the  
2 utterance comprises using an intonation model.

1 ~~24.~~ A method of operating an endpoint detector for speech recognition, the  
2 method comprising:  
3 inputting speech representing an utterance, the utterance having a time-  
4 varying fundamental frequency;  
5 determining an intonation of the utterance by  
6 computing the intonation as the fundamental frequency of the  
7 utterance as a function of time, and  
8 referencing the intonation against an intonation model to determine  
9 the intonation of the utterance;  
10 if the intonation of the utterance is determined to be generally decreasing,  
11 then setting a threshold time period equal to a first time value;  
12 if the intonation of the utterance is determined not to be generally  
13 decreasing, then setting the threshold time period equal to a second time value  
14 larger than the first time value; and  
15 using the threshold time period to identify an endpoint of the utterance, by  
16 determining that an endpoint of the utterance has occurred if the speech remains  
17 below a predetermined value for a length of time equal to the threshold time  
18 period.

1 25. A machine-readable program storage medium tangibly embodying a sequence  
2 of instructions executable by a machine to perform a method for endpoint  
3 detection, the method comprising:  
4       inputting speech representing an utterance, the utterance having an  
5 intonation; and  
6       identifying an endpoint of the utterance based on the intonation of the  
7 utterance.

1 26. A machine-readable program storage medium as recited in claim 25, wherein  
2 said using the intonation of the utterance in identifying an endpoint of the  
3 utterance comprises comparing the intonation of the utterance with an intonation  
4 model.

1 27. A machine-readable program storage medium as recited in claim 25, wherein  
2 the method further comprises determining the intonation of the utterance.

1 28. A machine-readable program storage medium as recited in claim 27, wherein  
2 said determining the intonation of the utterance comprises computing the  
3 fundamental frequency of the utterance.

1 29. A machine-readable program storage medium as recited in claim 27, wherein  
2 said determining the intonation of the utterance comprises using an intonation  
3 model to determine the intonation of the utterance.

1 30. A machine-readable program storage medium as recited in claim 25, wherein  
2 the method further comprises:  
3       determining a period of time for which an energy value of the speech has  
4 been below a threshold value; and  
5       wherein said identifying an endpoint of the utterance comprises identifying  
6 the endpoint of the utterance further based on the period of time.

1 31. A machine-readable program storage medium as recited in claim 25, wherein  
2 the method further comprises:  
3 determining a duration of a final syllable of the utterance; and  
4 wherein said identifying an endpoint of the utterance comprises identifying  
5 the endpoint of the utterance further based on the duration of a final syllable of  
6 the utterance.

1 32. A machine-readable program storage medium as recited in claim 31, wherein  
2 the method further comprises:  
3 determining a period of time that has elapsed since a value of the speech  
4 dropped below a threshold value; and  
5 wherein said identifying an endpoint of the utterance comprises identifying  
6 the endpoint of the utterance further based on the period of time.

1 33. An endpoint detector comprising:  
2 means for inputting speech representing an utterance, the utterance having  
3 an intonation; and  
4 means for identifying an endpoint of the utterance based on the intonation  
5 of the utterance.

1 34. An endpoint detector as recited in claim 33, wherein said means for using the  
2 intonation of the utterance in identifying an endpoint of the utterance comprises  
3 means for comparing the intonation of the utterance with an intonation model.

1 35. An endpoint detector as recited in claim 33, further comprising means for  
2 determining the intonation of the utterance.

1 36. An endpoint detector as recited in claim 35, wherein said means for  
2 determining the intonation of the utterance comprises means for computing the  
3 fundamental frequency of the utterance.



1 37. An endpoint detector as recited in claim 35, wherein said means for  
2 determining the intonation of the utterance comprises means for using an  
3 intonation model to determine the intonation of the utterance.

1 38. An endpoint detector as recited in claim 33, further comprising:  
2 means for determining a period of time that has elapsed since a value of the  
3 speech dropped below a threshold value; and  
4 wherein said means for identifying an endpoint of the utterance comprises  
5 means for identifying the endpoint of the utterance further based on the period of  
6 time.

1 39. An endpoint detector as recited in claim 33, further comprising:  
2 means for determining a duration of a final syllable of the utterance; and  
3 wherein said means for identifying an endpoint of the utterance comprises  
4 means for identifying the endpoint of the utterance further based on the duration  
5 of a final syllable of the utterance.

1 40. An endpoint detector as recited in claim 39, further comprising:  
2 means for determining a period of time that has elapsed since a value of the  
3 speech dropped below a threshold value; and  
4 wherein said means for identifying an endpoint of the utterance comprises  
5 means for identifying the endpoint of the utterance further based on the period of  
6 time.

1 ~~41~~. An apparatus for performing endpoint detection comprising:  
2 means for inputting speech representing an utterance, the utterance having  
3 a time-varying fundamental frequency;  
4 means for determining that a value of the speech has dropped below a  
5 threshold value;

6 means for computing an intonation of the utterance by determining the  
7 fundamental frequency of the utterance as a function of time;  
8 means for referencing the intonation of the utterance against an intonation  
9 model to determine a first end-of-utterance probability;  
10 means for determining a period of time that has elapsed since the speech  
11 dropped below the threshold value;  
12 means for referencing the period of time against an elapsed time model to  
13 determine a second end-of-utterance probability;  
14 means for referencing the duration of the final syllable of the utterance  
15 against a syllable duration model to determine a third end-of-utterance  
16 probability;  
17 means for computing an overall end-of-utterance probability as a function  
18 of the first, second, and third end-of-utterance probabilities; and  
19 means for determining whether an end-of-utterance has occurred by  
20 comparing the overall end-of-utterance probability to a threshold probability.